AD NO. ___________________________
DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-9735

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

BLIND GRID SCORING RECORD NO. 919

SITE LOCATION:
U.S. ARMY ABERDEEN PROVING GROUND

DEMONSTRATOR:
VF WARNER AND ASSOCIATES INC.
6832 OLD DOMINION DRIVE
SUITE 206
MCLEAN, VA 22101

TECHNOLOGY TYPE/PLATFORM:
EM AMOS/TOWED

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

JULY 2008

Prepared for:
U.S. ARMY ENVIRONMENTAL COMMAND
ABERDEEN PROVING GROUND, MD 21010-5401

U.S. ARMY DEVELOPMENTAL TEST COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

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This scoring record documents the efforts of VF Warner and Associates Inc. to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site Blind Grid Field. This Scoring Record was coordinated by J. Stephen McClung and the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Command, and the U.S. Army Aberdeen Test Center.

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1. The attached document entitled "Scoring Record No. 919" dated July 2008 is provided for review for public disclosure in accordance with AR 530-1 as supplemented. The document is proposed for public release via the internet.

2. I, the undersigned, am aware of the intelligence interest in open source publications and in the subject matter of the information I have reviewed for intelligence purposes. I certify that I have sufficient technical expertise in the subject matter of this document and that, to the best of my knowledge, the net benefit of this public release outweighs the potential damage to the essential secrecy of all related ATC, DTC, ATEC, Army or other DOD programs of which I am aware.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of munitions and explosives of concern (MEC) - i.e. unexploded ordnance (UXO) and discarded military munitions (DMM) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland, and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multiagency program spearheaded by the U.S. Army Environmental Command (USAEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP), and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that may vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time, and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-mm, 40-mm, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm HEAT Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb
	M75 Submunition

HEAT = high-explosive antitank.
JPG = Jefferson Proving Ground.

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

POC: Mr. Robert M Novogratz
(703) 448-0440

Address: VF Warner and Associates Inc.
6832 Old Dominion Drive, Suite 206
Mclean, VA 22101

2.1.2 System Description (provided by demonstrator)

a. The core component of the electromagnetic (EM) AMOS metal detector is a linear multichannel sensor array consisting of a 2-meter-wide transmitter coil and 16 receiver coils, mounted on a robust, all-terrain trailer (fig. 1).

b. The AMOS detector unit consists of the following main components:

(1) Lower sensor level (dimensions: 2.16 by 1.00 m).

(2) Upper sensor level (dimensions: 2.03 by 0.45 m).

(3) Reference coil level (dimensions: 0.51 by 0.49 m).

c. A special wheel-suspension system ensures that the measurement system operates parallel to the terrain surface at a constant distance from the ground. This design makes sure that reproducible signatures are generated. It also enables the data from the individual lanes to be combined into a complete map without the appearance of virtual objects.

d. The physical measurement principle is based on the verification of an induced eddy current in a metallic body. With AMOS, active stimulation occurs by impulses via a transmitter coil, whose eddy current is switched off in a time interval of several microseconds. Temporal alteration of the primary magnetic field generated by the transmitter coil induces an eddy current in a metallic body located within the primary field. Owing to the finite conductivity, the eddy current induced in the interior and exterior of the body diminishes exponentially as time elapses.

e. Scanning performance in hectares per hour (P = v x b): 0.7 ha/h.

With a scanning width (b) of: 1.8 m.

At a scanning velocity (v) of: 1.1 m/s.

f. Attainable accuracy of location (x,y):

With an object depth of <0.4 m	0.25 m (circular error)
With an object depth of 0.4 to 1.5 m	0.50 m (circular error)

g. Attainable accuracy of depth (z) $\pm$0.3 m

h. Detection performance for ferrous and nonferrous metals:

Will detect ammunition components 20-mm caliber and over at depths of up to 0.4 meter and ammunition components 100-mm caliber and over at depths of up to 1 meter.

Figure 1. Demonstrator's system, EM AMOS/towed.

2.1.3 <u>Data Processing Description (provided by demonstrator)</u>

a. The preprocessed sensor signals are recorded in a notebook computer and archived. These data are later used in producing an object location map and accompanying list of objects offline.

b. In order to enable an exact assignment of coordinates when mapping the location of objects, the current position of the sensor platform trailer is continuously calculated by means of a special differential Global Positioning System (GPS) (real-time kinematic (RTK)-GPS) and then recorded and linked with the corresponding measurement data and stored at the hard disk in a binary format.

c. During the scanning process, the following items appear in real time on the display of the operator's notebook computer:

(1) The position of the sensor platform.

(2) The actual route being traveled by the sensor platform trailer.

(3) The intended route of travel of the sensor platform trailer.

(4) The current measurement data, thereby ensuring complete coverage during scanning operations.

d. The incoming sensor signals and the accompanying RTK-GPS position coordinates are processed online. The 16-channel sensor electronics feature a resolution of 16 bits and a data repetition rate of 20 Hz per channel. The digitized measurement data and the RTK-GPS data are transmitted via an RS 232 interface.

e. The following software components are available for the acquisition, evaluation, and visualization of data:

(1) The MonMX data acquisition module.

(2) The DLMGPS GPS coordinates transformation module.

(3) MAGNETO® data evaluation and visualization module.

f. During measurement operations, the MonMX module carries out the time-synchronous recording of the GPS and sensor data on the Notebook. The real-time depiction of sensor data and visualization of the RTK-GPS status make it possible to conduct a qualitative evaluation of the measurement data during the actual measurement process. Moreover, to assure effective scanning of large areas, the current position of the vehicle, its direction of travel and the intended and actual path of the sensor platform are all depicted in real time. Following a measurement run, the recorded RTK-GPS information and sensor data are available on the notebook computer for further processing and analysis. The DLMGPS software is used for administering, transforming, and depicting the GPS data in various coordinate systems.

g. Various export functions enable the exchange of data with the system-inherent MAGNETO evaluation and visualization module, as well as the conversion of data for use in other geophysical software systems. With the aid of the MAGNETO software module, the

AMOS measurement data can be visualized and documented in various forms. This gives the user a rapid overview of the level of contamination in the area being scanned.

h. Furthermore, the module permits the interactive search for, and localization of, metallic objects within the scanned area. The position coordinates, depth, and diameter of suspicious objects are recorded on object lists and object maps.

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

a. QC.

(1) All information relating to an individual project is saved along with the measurement data itself. These are number of channels and their connection to information layers, relative position of sensors with respect to the GPS-antenna, compensation values for each channel and base naming convention for automatic data storage and file numbering. Sensors can be compensated for offsets automatically to reduce errors.

(2) The sensor carrier is towed by a suitable vehicle or pushed/pulled by the operator itself. During active data acquisition, a real-time navigation display shows the track along which the sensor array is being moved with selected or all project tracks already surveyed. The navigation display can be switched from autoscaling to following current position (moving-map display). QC with respect to the completeness of the surveyed area is ensured as any white space may be filled by navigating into the required areas to obtain maximum coverage. Where a survey baseline can be defined, parallel and suitably spaced survey lines can automatically be created.

b. QA. The MonMX software records 20 samples per second of sensor data. During data acquisition, the system maintains synchronisation to the GPS-timing, and all raw data are stored stamped with those time tags. Raw data are stored in multiple numbered files, where numbering can be automatic or under operator control. During measurements, a status line constantly provides information about quality of the GPS-positioning, number of available satellites, and synchronisation.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as Microsoft Word documents at www.uxotestsites.org.

2.2 APG SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area of APG. The Aberdeen Area of APG is located approximately 30 miles northeast of Baltimore at the northern end of the Chesapeake Bay. The Standardized Test Site encompasses 17 acres of upland and lowland flats, woods, and wetlands.

2.2.2 Soil Type

According to the soils survey conducted for the entire area of APG in 1998, the test site consists primarily of Elkton Series type soil (ref 2). The Elkton Series consists of very deep, slowly permeable, poorly drained soils. These soils formed in silty aeolin sediments and the underlying loamy alluvial and marine sediments. They are on upland and lowland flats and in depressions of the Mid-Atlantic Coastal Plain. Slopes range from 0 to 2 percent.

ERDC conducted a site-specific analysis in May of 2002 (ref 3). The results basically matched the soil survey mentioned above. Seventy percent of the samples taken were classified as silty loam. The majority (77 percent) of the soil samples had a measured water content between 15 and 30 percent with the water content decreasing slightly with depth.

For more details concerning the soil properties at the APG test site, go to www.uxotestsites.org on the Web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at APG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration grid	Contains 14 standard ordnance items buried in six positions at various angles and depths to allow demonstrator equipment calibration.
Blind grid	Contains 400 grid cells in a 0.2-hectare (0.5-acre) site. The center of each grid cell contains ordnance, clutter, or nothing.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (18 and 20 April 2007)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total numbers of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration lanes	0.00
Blind grid	1.83

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An APG weather station located approximately 1 mile west of the test site was used to record average temperature and precipitation on a half-hour basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 to 1700 hours while precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2007	Average Temperature, ^{o}F	Total Daily Precipitation, in.
18 April	49.3	0.00
20 April	62.3	0.00

3.3.2 Field Conditions

VF Warner surveyed the blind grid on 18 April 2007. The weather was cool and some puddles were present due to rain prior to testing.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: calibration, mogul, open field, and wooded areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. A two-person crew took 3 hours and 5 minutes to perform the initial setup and mobilization. There was no daily equipment preparation and no end of the day equipment break down.

3.4.2 Calibration. VF Warner spent no recordable time in the calibration lanes.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, demonstration site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to demonstration site issues. Demonstration site issues, while noted in the daily log, are considered nonchargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total site survey area.

3.4.3.1 Equipment/data checks, maintenance

Equipment data checks and maintenance activities accounted for 35 minutes of site usage time. These activities included changing out batteries and performing routine data checks to ensure the data were being properly recorded/collected. VF Warner spent no additional time for breaks and lunches.

3.4.3.2 Equipment failure or repair. No time was needed to resolve equipment failures that occurred while surveying the blind grid.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection. VF Warner spent a total of 1 hour and 50 minutes in the blind grid area, 1 hour and 15 minutes of which were spent collecting data.

3.4.5 Demobilization

The VF Warner survey crew went on to conduct a full demonstration of the site. Therefore, demobilization did not occur until 20 April 2007. On that day, it took the crew 3 hours and 45 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

VF Warner submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data was provided January 2008.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Geophysics: Dr. Andreas Fischer
Geophysics: Dr. Kay Winkelmann
Advisor: Bob Novogratz

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

VF Warner surveyed the blind grid in a linear manner. The line spacing used was the width of the array itself.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 2 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Both probabilities plotted against their respective probability of background alarm is shown in Figure 3. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

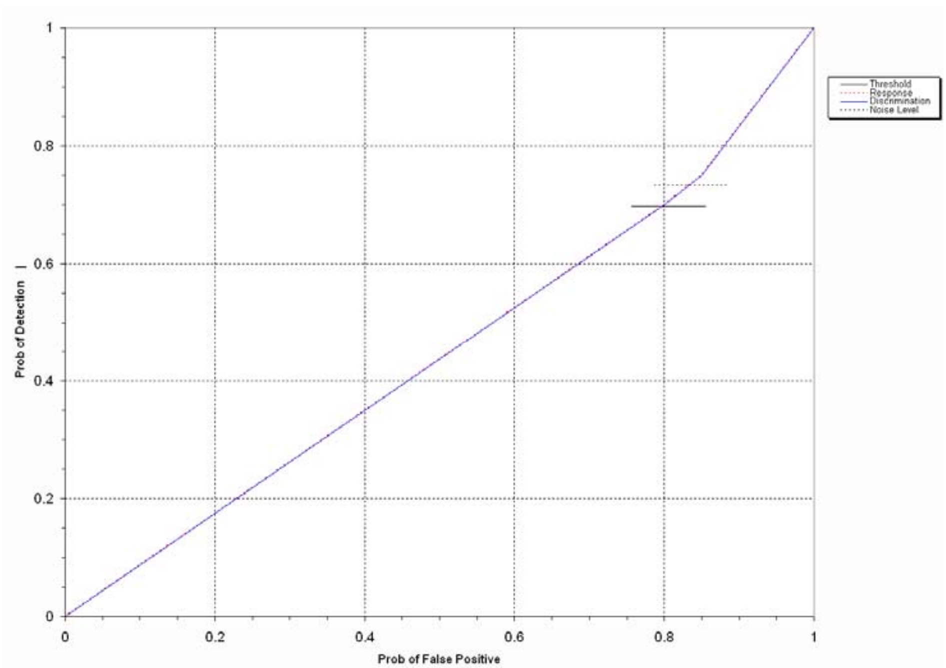

Figure 2. EM AMOS/towed blind grid probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

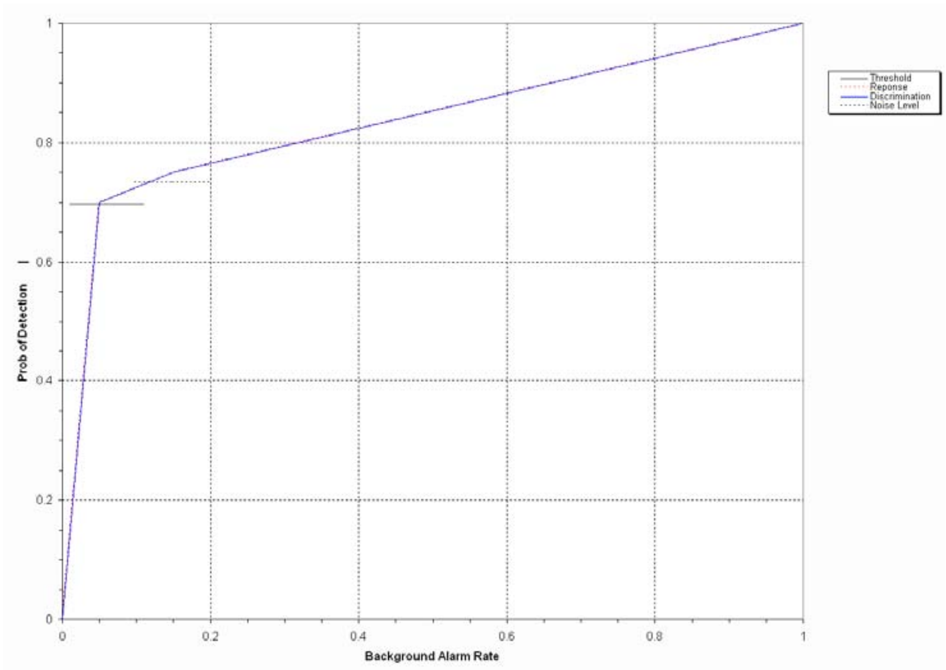

Figure 3. EM AMOS/towed blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

The probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20 mm are scored are shown in Figure 4. Both probabilities plotted against their respective probability of background alarm are shown in Figure 5. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

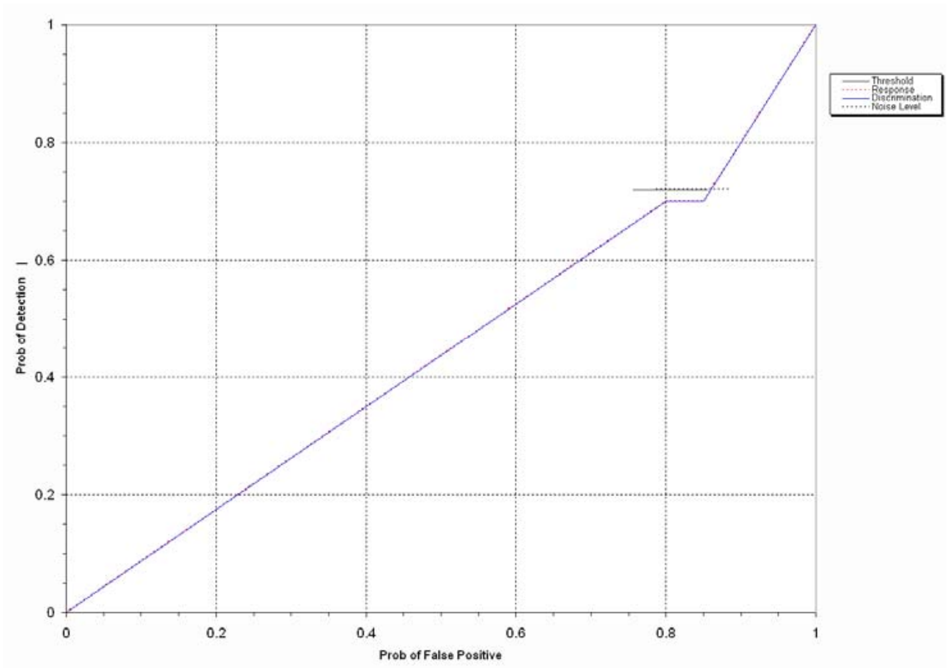

Figure 4. EM AMOS/towed blind grid probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

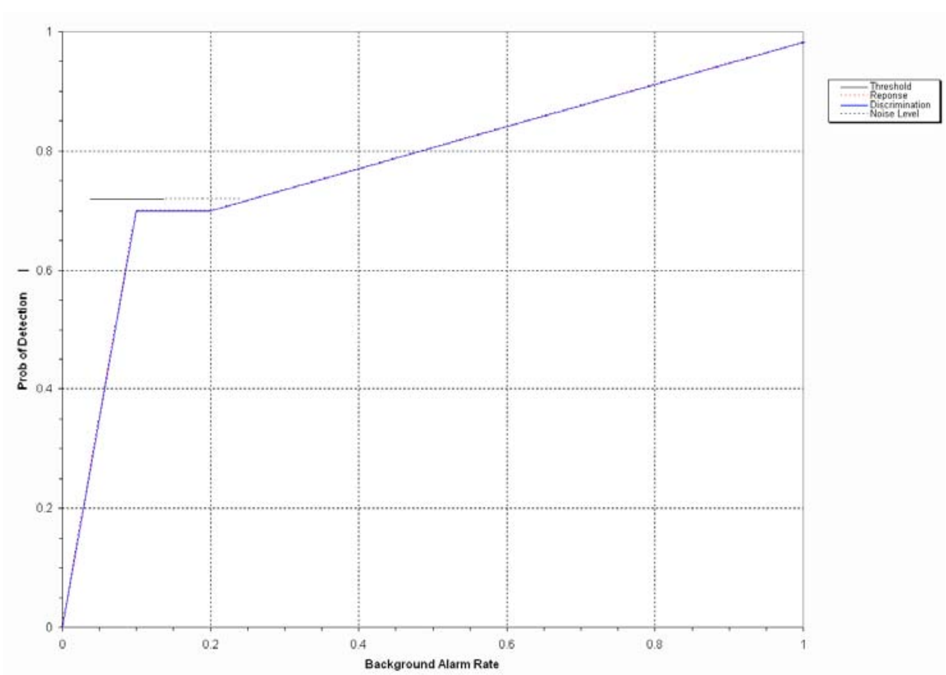

Figure 5. EM AMOS/towed blind grid probability of detection for response and discrimination stages versus their respective probabilities of background alarm for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the blind grid test broken out by size, depth, and nonstandard ordnance are presented in Table 5 (for cost results, see section 5). Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range (see app A for size definitions). The results are relative to the number of ordnance items emplaced. Depth is measured from the geometric center of anomalies.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90 percent confidence limit on probability of detection and P_{fp} was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 5 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 5. SUMMARY OF BLIND GRID RESULTS FOR THE EM AMOS

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.75	0.80	0.65	0.75	0.65	0.80	0.95	0.70	0.30
P_d Low 90% Conf	0.66	0.69	0.54	0.66	0.54	0.55	0.89	0.56	0.16
P_d Upper 90% Conf	0.79	0.86	0.76	0.85	0.78	0.95	1.00	0.79	0.50
P_{fp}	0.85	-	-	-	-	-	0.85	0.85	0.65
P_{fp} Low 90% Conf	0.78	-	-	-	-	-	0.76	0.75	0.33
P_d Upper 90% Conf	0.88	-	-	-	-	-	0.92	0.90	0.91
P_{ba}	0.15	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.70	0.75	0.60	0.70	0.65	0.80	0.90	0.70	0.30
P_d Low 90% Conf	0.63	0.67	0.48	0.59	0.54	0.55	0.78	0.56	0.16
P_d Upper 90% Conf	0.76	0.84	0.71	0.79	0.78	0.95	0.95	0.79	0.50
P_{fp}	0.80	-	-	-	-	-	0.85	0.80	0.65
P_{fp} Low 90% Conf	0.75	-	-	-	-	-	0.76	0.69	0.33
P_d Upper 90% Conf	0.86	-	-	-	-	-	0.92	0.86	0.91
P_{ba}	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.50.
Recommended Discrimination Stage Threshold: 1.50.

Note: The recommended discrimination stage threshold values are provided by the demonstrator.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 6.

TABLE 6. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.95	0.04	0.59
With No Loss of P_d	1.00	0.00	0.00

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 7). Correct type examples include 20-mm projectile, 105-mm HEAT Projectile, and 2.75-inch Rocket. A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard types for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 7. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	Percentage Correct
Small	0.0
Medium	0.0
Large	0.0
Overall	0.0

Note: The demonstrator did not attempt to provide type classification.

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 8. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the blind grid, only depth errors are calculated because (X, Y) positions are known to be the centers of each grid square.

TABLE 8. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Depth	-0.07	0.25

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated supervisor, the second person was designated data analyst, and the third and following personnel were considered field support. Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, data collection, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 9. Note that calibration time includes time spent in the calibration lanes as well as field calibrations. Site survey time includes daily setup/stop time, data collection, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 9. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
Initial setup				
Supervisor	1	$95.00	3.08	$292.60
Data analyst	1	57.00	3.08	175.56
Field support	0	28.50	0.00	0.00
Subtotal				**$468.16**
Calibration				
Supervisor	0	$95.00	0.00	$0.00
Data analyst	0	57.00	0.00	0.00
Field support	0	28.50	0.00	0.00
Subtotal				**$0.00**
Site survey				
Supervisor	1	$95.00	1.83	$173.85
Data analyst	1	57.00	1.83	104.31
Field support	0	28.50	0.00	0.00
Subtotal				**$278.16**

See notes at end of table.

TABLE 9 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
Demobilization				
Supervisor	1	$95.00	3.75	$356.25
Data analyst	1	57.00	3.75	213.75
Field support	0	28.50	0.00	0.00
Subtotal				**$570.00**
Total				**$1316.32**

Notes: Calibration time includes time spent in the calibration lanes as well as calibration before each data run.
Site survey time includes daily setup/stop time, data collection, breaks/lunch, and downtime due to system maintenance, failure, and weather.

SECTION 6.   COMPARISON OF RESULTS TO DATE

No comparisons to date.

SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Munitions and Explosives Of Concern (MEC): Specific categories of military munitions that may pose unique explosive safety risks, including UXO as defined in 10 USC 101(e)(5), DMM as defined in 10 USC 2710(e)(2) and/or munitions constituents (e.g. TNT, RDX) as defined in 10 USC 2710(e)(3) that are present in high enough concentrations to pose an explosive hazard.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-pound bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the blind grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/(No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to non-ordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

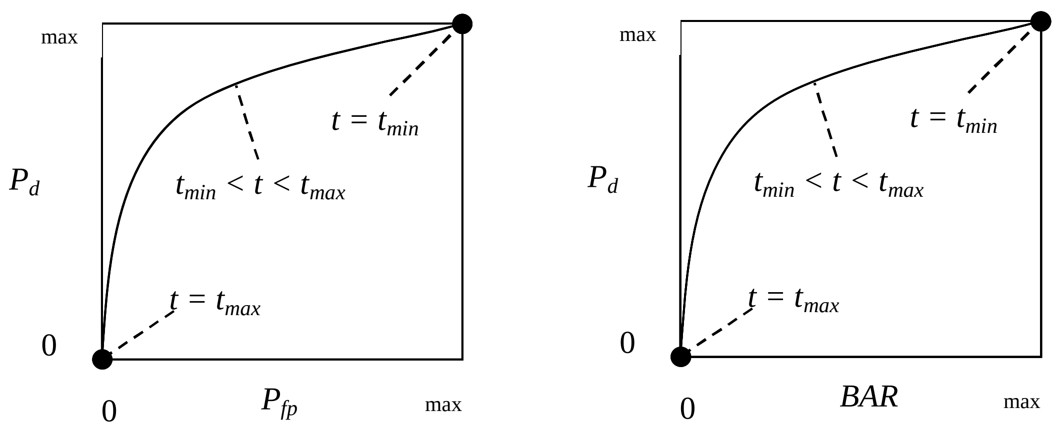

Figure A-1. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a pre-determined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the blind grid test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage t_{min}) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$.

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

CHI-SQUARE COMPARISON EXPLANATION:

The Chi-square test for differences in probabilities (or 2 x 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations.

A 2 x 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to determine if there is reason to believe that the proportion of ordnance correctly detected/discriminated by demonstrator X’s system is significantly degraded by the more challenging terrain feature introduced. The test statistic of the 2 x 2 contingency table is the

Chi-square distribution with one degree of freedom. Since an association between the more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A significance level of 0.05 is chosen which sets a critical decision limit of 2.71 from the Chi-square distribution with one degree of freedom. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, the proportions are considered to be significantly different.

Standardized UXO Technology Demonstration Site examples, where blind grid results are compared to those from the open field and open field results are compared to those from one of the scenarios, follow. It should be noted that a significant result does not prove a cause and effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying each of the three progressively more difficult areas using the same system (results indicate the number of ordnance detected divided by the number of ordnance emplaced):

	Blind grid	Open field	Moguls
P_d^{res}	100/100 = 1.0	8/10 = .80	20/33 = .61
P_d^{disc}	80/100 = 0.80	6/10 = .60	8/33 = .24

P_d^{res}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the response stage, all 100 ordnance out of 100 emplaced ordnance items were detected in the blind grid while 8 ordnance out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system.

P_d^{disc}: BLIND GRID versus OPEN FIELD. Using the example data above to compare probabilities of detection in the discrimination stage, 80 out of 100 emplaced ordnance items were correctly discriminated as ordnance in blind grid testing while 6 ordnance out of 10 emplaced were correctly discriminated as such in open field-testing. Those four values are used to calculate a test statistic of 1.12. Since the test statistic is less than the critical value of 2.71, the two discrimination stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{res}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the response stage, 8 out of 10 and 20 out of 33 are used to calculate a test statistic of 0.56. Since the test statistic is less than the critical value of 2.71, the two response stage detection rates are considered to be not significantly different at the 0.05 level of significance.

P_d^{disc}: OPEN FIELD versus MOGULS. Using the example data above to compare probabilities of detection in the discrimination stage, 6 out of 10 and 8 out of 33 are used to calculate a test statistic of 2.98. Since the test statistic is greater than the critical value of 2.71, the smaller discrimination stage detection rate is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause and effect relationship exists between the change in survey area and degradation in performance, it does indicate that the ability of demonstrator X to correctly discriminate seems to have been degraded by the mogul terrain relative to results from the flat open field using the same system.

APPENDIX B. DAILY WEATHER LOGS

Date, 07	Time, EST	Average temperature, °F	Total precipitation, in.
16 Apr	700	44.2	0.00
16 Apr	800	45.3	0.00
16 Apr	900	46.0	0.00
16 Apr	1000	46.6	0.00
16 Apr	1100	45.0	0.00
16 Apr	1200	45.0	0.00
16 Apr	1300	45.3	0.00
16 Apr	1400	45.3	0.00
16 Apr	1500	43.5	0.00
16 Apr	1600	44.2	0.00
16 Apr	1700	45.0	0.00
17 Apr	700	45.1	0.00
17 Apr	800	45.7	0.00
17 Apr	900	46.6	0.00
17 Apr	1000	47.3	0.00
17 Apr	1100	49.3	0.00
17 Apr	1200	52.7	0.00
17 Apr	1300	54.1	0.00
17 Apr	1400	53.4	0.00
17 Apr	1500	52.9	0.00
17 Apr	1600	52.3	0.00
17 Apr	1700	52.2	0.00
18 Apr	700	43.9	0.00
18 Apr	800	46.2	0.00
18 Apr	900	48.2	0.00
18 Apr	1000	48.2	0.00
18 Apr	1100	48.7	0.00
18 Apr	1200	49.1	0.00
18 Apr	1300	50.7	0.00
18 Apr	1400	51.8	0.00
18 Apr	1500	51.6	0.00
18 Apr	1600	52.0	0.00
18 Apr	1700	52.0	0.00
19 Apr	700	48.0	0.00
19 Apr	800	49.6	0.00
19 Apr	900	50.7	0.00
19 Apr	1000	50.4	0.00
19 Apr	1100	51.3	0.00
19 Apr	1200	53.1	0.00
19 Apr	1300	52.9	0.00
19 Apr	1400	53.8	0.00
19 Apr	1500	54.7	0.00
19 Apr	1600	55.0	0.00
19 Apr	1700	55.6	0.00

Date, 07	Time, EST	Average temperature, °F	Total precipitation, in.
20 Apr	700	44.8	0.00
20 Apr	800	51.6	0.00
20 Apr	900	56.7	0.00
20 Apr	1000	59.9	0.00
20 Apr	1100	63.0	0.00
20 Apr	1200	65.5	0.00
20 Apr	1300	66.7	0.00
20 Apr	1400	67.8	0.00
20 Apr	1500	68.9	0.00
20 Apr	1600	69.6	0.00
20 Apr	1700	70.3	0.00

APPENDIX C.   SOIL MOISTURE

Date: 16 Apr 07			
Times: 1000 am to 1600 pm			
Probe Location	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	55.2	55.6
	6 to 12	48.7	49.8
	12 to 24	69.3	69.7
	24 to 36	68.7	69.3
	36 to 48	72.2	72.1
Wooded area	0 to 6	NA	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open area	0 to 6	38.7	38.5
	6 to 12	39.3	39.4
	12 to 24	45.1	44.8
	24 to 36	48.3	48.6
	36 to 48	49.2	49.6
Calibration lanes	0 to 6	11.2	11.4
	6 to 12	15.9	15.7
	12 to 24	24.7	24.9
	24 to 36	28.9	28.8
	36 to 48	32.3	32.3
Blind grid/moguls	0 to 6	12.7	12.8
	6 to 12	10.2	10.4
	12 to 24	24.8	24.7
	24 to 36	18.8	18.9
	36 to 48	26.3	26.3

Date: 17 Apr 07			
Times: 0900 am to 1400 pm			
Probe Location	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	55.7	55.6
	6 to 12	48.7	49.8
	12 to 24	69.3	69.7
	24 to 36	68.7	69.3
	36 to 48	72.2	72.1
Wooded area	0 to 6	NA	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open area	0 to 6	38.8	38.6
	6 to 12	39.7	39.8
	12 to 24	45.3	45.3
	24 to 36	48.9	48.7
	36 to 48	49.8	49.7
Calibration lanes	0 to 6	11.7	11.8
	6 to 12	15.8	15.5
	12 to 24	24.9	24.5
	24 to 36	29.2	29.1
	36 to 48	33.3	33.3
Blind grid/moguls	0 to 6	12.9	12.8
	6 to 12	10.7	10.6
	12 to 24	25.2	25.3
	24 to 36	19.4	19.1
	36 to 48	26.8	26.7

Date: 18 Apr 07			
Times: 1000 am to 1445 pm			
Probe Location	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	55.5	55.3
	6 to 12	48.6	48.6
	12 to 24	69.5	69.4
	24 to 36	68.9	68.8
	36 to 48	72.0	71.7
Wooded area	0 to 6	NA	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open area	0 to 6	38.5	38.4
	6 to 12	39.7	39.5
	12 to 24	45.0	44.9
	24 to 36	48.4	48.3
	36 to 48	49.5	49.6
Calibration lanes	0 to 6	11.5	11.4
	6 to 12	15.7	15.6
	12 to 24	24.3	24.4
	24 to 36	29.1	28.7
	36 to 48	33.7	33.6
Blind grid/moguls	0 to 6	12.5	12.6
	6 to 12	10.5	10.4
	12 to 24	25.1	25.0
	24 to 36	18.9	18.8
	36 to 48	26.6	26.5

Date: 19 Apr 07			
Times: 1000 am to 1400 pm			
Probe Location	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	55.2	55.2
	6 to 12	48.5	48.4
	12 to 24	69.2	69.3
	24 to 36	68.6	68.4
	36 to 48	71.5	71.3
Wooded area	0 to 6	NA	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open area	0 to 6	38.3	38.2
	6 to 12	39.4	39.3
	12 to 24	44.7	44.6
	24 to 36	48.2	48.1
	36 to 48	49.4	49.3
Calibration lanes	0 to 6	11.2	11.1
	6 to 12	15.5	15.3
	12 to 24	24.1	24.0
	24 to 36	28.5	28.4
	36 to 48	33.5	33.3
Blind grid/moguls	0 to 6	12.4	12.2
	6 to 12	10.3	10.3
	12 to 24	24.8	24.7
	24 to 36	18.6	18.5
	36 to 48	26.3	26.4

Date: 20 Apr 07			
Times: 1100 am to 1600 pm			
Probe Location	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	55.1	55.0
	6 to 12	48.1	48.1
	12 to 24	69.1	69.0
	24 to 36	68.4	68.1
	36 to 48	71.2	71.0
Wooded area	0 to 6	NA	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open area	0 to 6	38.2	38.0
	6 to 12	39.3	39.1
	12 to 24	44.4	44.4
	24 to 36	48.0	47.7
	36 to 48	49.2	48.8
Calibration lanes	0 to 6	11.1	11.0
	6 to 12	15.2	15.2
	12 to 24	23.7	23.5
	24 to 36	28.2	28.1
	36 to 48	33.3	33.4
Blind grid/moguls	0 to 6	12.1	12.0
	6 to 12	10.2	10.1
	12 to 24	24.5	24.4
	24 to 36	18.2	18.1
	36 to 48	26.2	26.0

APPENDIX D. DAILY ACTIVITY LOG

Date, 07	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min.	Operational Status	Operational Comments	Pattern	Field Conditions
18 Apr	2	CALIBRATION LANES	900	1205	185	INITIAL SETUP	MOBILIZATION	LINEAR	SUNNY MUDDY
18 Apr	2	BLIND GRID	1205	1320	75	COLLECTING DATA	COLLECTING DATA 1/2-IN. BLIND GRID AND 1/2-IN. CALIBRATION LANE 1/3, EAST TO WEST	LINEAR	SUNNY MUDDY
18 Apr	2	BLIND GRID	1320	1355	35	DOWNTIME DUE TO EQUIPMENT MAINTENANCE/CHECK	DATA CHECK	LINEAR	SUNNY MUDDY
18 Apr	2	OPEN FIELD	1355	1550	115	COLLECTING DATA	COLLECT DATA	LINEAR	SUNNY MUDDY
18 Apr	2	OPEN FIELD	1550	1615	25	DAILY START, STOP	EQUIPMENT BREAKDOWN	LINEAR	SUNNY MUDDY
19 Apr	2	OPEN FIELD	710	745	35	DAILY START, STOP	SET UP EQUIPMENT	LINEAR	CLOUDY MUDDY
19 Apr	2	OPEN FIELD	745	935	110	COLLECTING DATA	COLLECT DATA	LINEAR	CLOUDY MUDDY
19 Apr	2	OPEN FIELD	935	950	15	BREAK/LUNCH	BREAK	LINEAR	CLOUDY MUDDY
19 Apr	2	OPEN FIELD	950	1335	225	COLLECTING DATA	COLLECT DATA	LINEAR	CLOUDY MUDDY
19 Apr	2	OPEN FIELD	1335	1350	15	BREAK/LUNCH	BREAK	LINEAR	CLOUDY MUDDY
19 Apr	2	OPEN FIELD	1350	1730	220	COLLECTING DATA	COLLECT DATA	LINEAR	CLOUDY MUDDY
19 Apr	2	OPEN FIELD	1730	1750	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	LINEAR	CLOUDY MUDDY
20 Apr	2	OPEN FIELD	1010	1355	225	DEMOBILIZATION	DEMOBILIZATION	LINEAR	SUNNY MUDDY

Note: Activities pertinent to this specific demonstration are indicated in highlighted text.

APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

4. Yuma Proving Ground Soil Survey Report, May 2003.

APPENDIX F. ABBREVIATIONS

APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
DMM	=	discarded military munitions
EM	=	electromagnetic
ERDC	=	U.S. Army Corps of Engineers Engineer Research and Development Center
EST	=	Eastern Standard Time
ESTCP	=	Environmental Security Technology Certification Program
EQT	=	Army Environmental Quality Technology Program
GPS	=	Global Positioning System
HEAT	=	high explosive antitank
JPG	=	Jefferson Proving Ground
MEC	=	munitions and explosives of concern
NS	=	nonstandard
POC	=	point of contact
QA	=	quality assurance
QC	=	quality control
ROC	=	receiver-operating characteristic
RTK	=	real-time kinematic
SERDP	=	Strategic Environmental Research and Development Program
USAEC	=	U.S. Army Environmental Command
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

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